RANDOM SAMPLING OF CONSTRUCTION MATERIALS

Significance

Sampling and testing are two of the most important functions in quality assurance and quality control (QA & QC). Data from the tests are the tools with which the quality of products is controlled, and on which acceptance is based. For this reason, great care must be used in following standardized sampling and testing procedures.

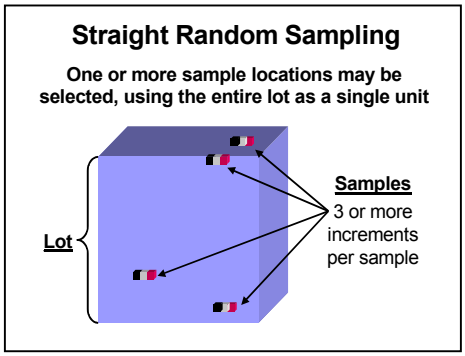
In controlling operations, it is necessary to obtain numerous samples at various points during production or installation of construction materials. Unless precautions are taken, sampling can occur in patterns that may impart a bias to the data gathered. Sampling at the same time, say noon, each day may jeopardize the effectiveness of any quality program. This might occur, for example, because a material producer does certain operations, such as cleaning screens at an aggregate plant, late in the morning each day. To obtain a representative sample, a reliable system of random sampling must be employed.

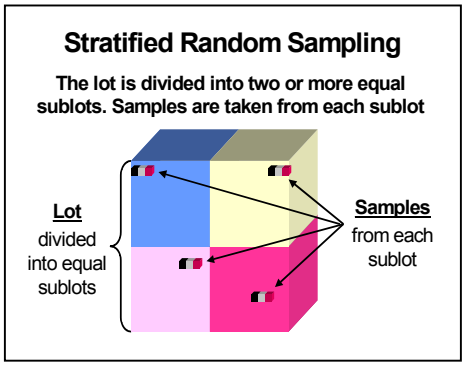
Scope

The procedure presented here eliminates bias in sampling materials. Randomly selecting a set of numbers from a table, calculator, or computer will eliminate the possibility for bias. Random numbers are used to identify sampling times, locations, or points within a lot or sublot. This method does not cover how to sample, but rather how to determine where or when to sample.

Sampling Concepts

A lot is the quantity of material evaluated by QA or QC procedures. A lot is a preselected quantity that may represent hours of production, a quantity or number of loads of material, or an interval of time. A lot may be comprised of several portions that are called sublots or units. The number of sublots comprising a lot will be determined by the agency's specifications.





Straight Random Sampling vs. Stratified Random Sampling: Straight random sampling considers an entire lot as a single unit and determines each sample location based on the entire lot size. Stratified random sampling divides the lot into a specified number of sublots or units and then determines each sample location within a distinct sublot. Both methods result in random distribution of samples to be tested for compliance with the agency's specification.

Agencies stipulate when to use straight random sampling or stratified random sampling. AASHTO T 2, Sampling of Aggregates, for example, specifies a straight random sampling procedure.

Picking Random Numbers from a Table

Table 1 contains pairs of numbers. The first number is the "pick" number and the second is the Random Number, "RN". The table was generated with a spreadsheet and the cells (boxes at the intersection of rows and columns) containing the RNs actually contain the "random number function". Every time the spreadsheet is opened or changed, all the RNs change.

- Select a Pick number in a random method. The first two or last two digits in the next automobile license plate you see would be one way to select. Another would be to start a digital stop watch and stop it several seconds later, using the decimal part of the seconds as your Pick number.
- Find the RN matching the Pick number.

TABLE 1
Random Numbers

Pick	RN	Pick	RN	Pick	RN	Pick	RN	Pick	RN
01	0.998	21	0.758	41	0.398	61	0.895	81	0.222
02	0.656	22	0.552	42	0.603	62	0.442	82	0.390
03	0.539	23	0.702	43	0.150	63	0.821	83	0.468
04	0.458	24	0.217	44	0.001	64	0.187	84	0.335
05	0.407	25	0.000	45	0.521	65	0.260	85	0.727
06	0.062	26	0.781	46	0.462	66	0.815	86	0.708
07	0.370	27	0.317	47	0.553	67	0.154	87	0.161
08	0.410	28	0.896	48	0.591	68	0.007	88	0.893
09	0.923	29	0.848	49	0.797	69	0.759	89	0.255
10	0.499	30	0.045	50	0.638	70	0.925	90	0.604
11	0.392	31	0.692	51	0.006	71	0.131	91	0.880
12	0.271	32	0.530	52	0.526	72	0.702	92	0.656
13	0.816	33	0.796	53	0.147	73	0.146	93	0.711
14	0.969	34	0.100	54	0.042	74	0.355	94	0.377
15	0.188	35	0.902	55	0.609	75	0.292	95	0.287
16	0.185	36	0.674	56	0.579	76	0.854	96	0.461
17	0.809	37	0.509	57	0.887	77	0.240	97	0.703
18	0.105	38	0.013	58	0.495	78	0.851	98	0.866
19	0.715	39	0.497	59	0.039	79	0.678	99	0.616
20	0.380	40	0.587	60	0.812	80	0.122	00	0.759

Picking Random Numbers with a Calculator or Computer

Many calculators and computer programs have a built-in random number function. To obtain a random number, key in the code or push the button(s) the calculator's instructions call for. The display will show a number between 0.000 and 1.000 and this will be your random number.

Documentation

Documentation of random number (RN) selection is as important as determining the RN's, since it is critical to proper record keeping to show how they were obtained. In addition to listing the RN's, the documentation should describe who obtained them, what assumptions or specifications governed their selection, and a specific reference as to the source.

Examples of Random Sampling Procedures Using Random Numbers

Agencies often specify the frequency of sampling in terms of mass of production, time, number of haul units, or amount of in-place material.

- **Sampling Based on Mass of Production:**

The specification might call for one sample from every 1000 Tons (T) of aggregate. If the random number was 0.317, the sample would be taken at (0.317)(1000 T) = 317 T.

- **Sampling Based on Time:**

One sample per day might also be specified. If the day were 9 hours long and the random number 0.199, the sample would be taken at (0.199)(9 hrs) = 1.79 hr = 1 hr, 47 minutes into the day. AASHTO T 2 permits this time to be rounded to the nearest 5 minutes.

- **Sampling from Haul Units:**

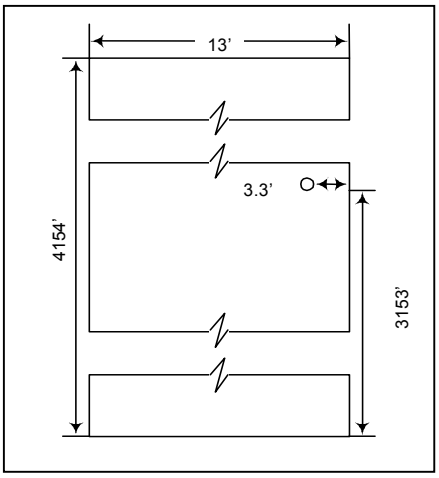
Based on the agency's specifications (in terms of time, volume, or mass) determine the number of haul units that comprise a lot. Multiply the selected random number(s) by the number of units to determine which unit(s) will be sampled.

For example, if 20 haul units comprise a lot and one sample is needed, pick one RN. If the RN were 0.773, then the sample would be taken from the (0.773)(20) = 15.46, or 16th haul unit.

- **Sampling from a Roadway with Previously Placed Material:**

The agency's specified frequency of sampling (in time, volume, or mass) can be translated into a location on a job. In this example one sample per lot is required. Given that the size of the lot is equal to 1000yd^3 and material is being placed 0.50' thick and 13' wide, then the lot is 4154' long.

$$\frac{1000\ yd^3 \times 27}{13' \times 0.5'} = 4154'$$



Sampling From a Roadway

In this case, you would select two RNs to determine the coordinates of the sample location. For example, a first RN of 0.759 would specify that the sample would be taken at (0.759)(4154') = 3153' from the beginning. A second RN of 0.255 would specify that the sample would be taken at (0.255)(13') = 3.3' from the right edge.

To avoid problems associated with taking samples too close to the edge, no sample is taken closer than 1' to the edge. If the RN specifies a location closer than 1', then 1' is added to or subtracted from the distance calculated.

- **Sampling from a Stockpile:**

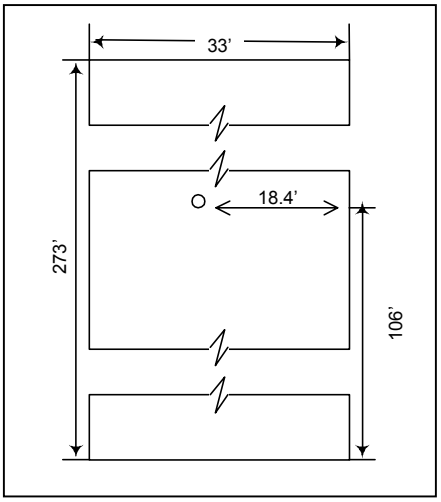
AASHTO T 2 recommends against sampling from stockpiles. However, some agencies use random procedures in determining sampling locations from a stockpile. Stockpiles are prone to segregation and a sample obtained from a stockpile may not be representative. Refer to AASHTO T 2 for guidance on how to sample from a stockpile.

- **In-Place Density Testing:**

In the following example a lot is one days production, divided into sublots of 1000 yd^2, requiring one test per sublot. If material is being placed 33' wide, then the sublot is 273' long.

$$\frac{1000\ yd^2 \times 9}{33'} = 273'$$

You would select two RNs to determine the coordinates of the test location within the sublot. A first RN of 0.387 would specify that the sample would be taken at (0.387)(273') = 106' from the beginning. A second RN of 0.558 would specify that the sample would be taken at (0.558)(33') = 18.4' from the right edge. If the RN specifies a location closer than 1' to the edge, then 1' is added to or subtracted from the distance calculated.



In-Place Density Testing

Summary

It is critical that technicians and engineers understand the significance of randomly determining sample and test locations or intervals. Use of random numbers, and application of the principles introduced in this section, gives every portion of the lot or sublot an equal chance of being sampled or tested without introduction of bias.

It is also important to accurately document the assumptions and/or specifications governing random number generation, and what method was used to obtain them.